Space Weather Technical Forecast

Issued on Sunday, 15 September 2024 at 01:29 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: M-class flares likely with a slight chance of further X-class flares. Chance of G1-G2/Minor-Moderate storms on days 1 and 3 (15 and 17 Sep), these expected day 2 (16 Sep) with a chance of G3/Strong storms and a slight chance of G4/Severe storms due to a fast CME arrival.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: High with a X4.5 flare observed at 14/1528 UTC originating from AR2825 in the southeast.

There are seven sunspot regions on the disc with the most active being AR3825. It is a compact and magnetically complex region, containing at least one delta spot with a history of multiple M class and another X class flare in recent days. A rapid adjustment in the penumbra around the trailing spot was observed at the time of the most recent X class flare, this is where the delta is located, with an inherently unstable north-south magnetic alignment. AR3814 in the northeast remains generally unchanged, whilst AR3824 in south centre continues to fade. AR3826 to the south of AR3824 has continued to emerge, but remains a small, simple bipolar group. The remaining regions are generally small, with limited magnetic complexity and activity at this time, whilst both AR3813 & AR3816 have faded whilst rotating off the disk.

A CME that was observed from AR3825 in the southeast occurring from the above X4.5 flare has been analysed as having an Earth-directed impact on day 2 (16 Sep). Numerous other CMEs were observed but these are not deemed to be Earth-directed.

Solar Wind / Geomagnetic Activity: Solar wind parameters, as observed by ACE at L1, were indicative of continued residual CME magnetic cloud effects. Solar wind speeds were slightly elevated, ranging from 400-500 km/s. Density was a little below average. The Interplanetary Magnetic Field (IMF) Bt, was Weak to Moderate, between 6-10nT, while the north-south component, Bz, remained largely negative, peaking -8nT. Phi angle was largely positive (away from the Sun). The net result of these parameters was for mostly Unsettled to Active geomagnetic activity (Kp 3-4).

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux observed by GOES18 has steadily risen since the X4.5 flare but has levelled off at moderate levels. High energy electron flux (greater than 2MeV) observed by GOES16, generally varied on a diurnal cycle between background and Moderate levels, peaking at 740pfu at 14/0415 UTC. The associated 24-hour fluence showed a generally flat trend, with 2.43e7 integrated pfu observed at 15/0000UTC.

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Met Office Space Weather Technical Forecast

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate to High activity is expected, with M-flares likely and a slight chance of further X-class flares. These most likely from AR3825 in the southeast.

Solar Wind / Geomagnetic Activity: There are up to 3 CME arrivals and the potential for up to 3 coronal hole fast winds which feature in the forecast. The most significant feature is the 14 Sep CME which may bring Strong or Very Strong solar winds at Earth on day 2 (16 Sep), with a small chance this may arrive early, by late day 1 (15 Sep). This feature may have lingering effects into day 3 (17 Sep) combined with the second coronal hole fast wind. The final coronal hole fast wind may arrive day 4, with slightly elevated to elevated speeds expected.

Generally Quiet to Active geomagnetic activity is expected day 1 (15 Sep) with a chance of G1-2/Minor-Moderate and an outside chance of G3-5/Strong-Extreme storms should the 14 Sep CME arrive early with more potency than currently expected. The 14 Sep CME should then arrive with glancing impacts some time on day 2 (16 Sep) with G1-2/Minor-Moderate expected and a chance of G3/Strong and a slight chance of G4-5/Severe-Extreme storms. These risks gradually step-down into days 3 and 4 (17 and 18 Sep) due to waning CME and coronal hole fast wind effects.

Energetic Particles / Solar Radiation: High energy proton flux at GOES-18 has risen to moderate levels after the X4.5 flare on 14 Sep. There is therefore a chance that S1 proton storm levels may be reached day 1 (15 Sep), this risk reducing later in the period. High energy electron flux is expected to remain mainly at Background to Moderate with the associated 24 hour fluence remaining below Active.

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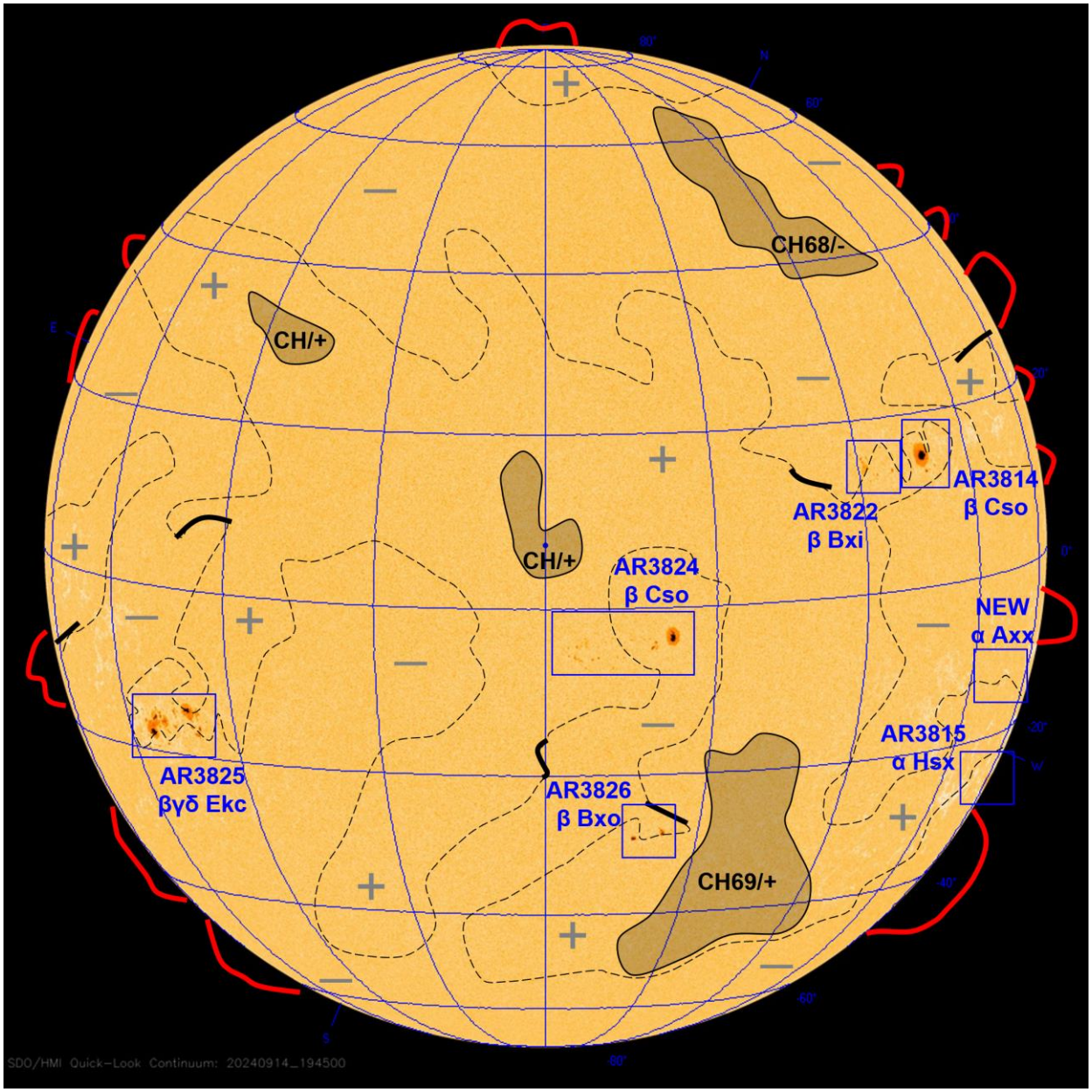
Figure 1. Solar Analysis Valid 14/1945UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The CME that arrived on 12 Sep resulted in disturbed geomagnetic conditions that are still ongoing with background to slightly elevated solar winds. A further CME arrival was forecast to arrive early on day 1 (14 Sep) but has not yet been detected at L1 (at time of writing). This originated from the same sunspot as 12 Sep CME arrival, AR3814, from an M1.0 flare at 10/2350 UTC. This CME was slower and more diffuse however, suggesting a weaker arrival and carries low confidence.

A CME was observed leaving the sun at around 13/0930 UTC, the result of a filament eruption, most likely associated with the M2.9 flare observed at 13/0835 UTC from AR3814. Its analysis revealed that the bulk of the ejecta is expected to pass ahead of Earth's orbit towards Stereo-A, however it may give a glancing blow on day 2 (16 Sep).

The final and most significant CME in the period originated from the X4.5 flare from AR3825 at 14/1528UTC. This spot was located around 55 degrees east at this time of the eruption, with subsequent analysis showing significant material being ejected directly away from the source in a narrow cone, but with a wider region of material also evident, this has been modelled with an arrival most likely during day 2 (16 Sep). There was also evidence of a faster shock visible beyond the opposing side of the Sun, giving clear Earth impacts from this shock also which may interact with Earth from very late on day 1 (15 Sep) before the bulk of the material arrives.

Aside from these arrivals, there are also up to three coronal holes which may influence the forecast. CH68/- is the most westward of these, with any high speed stream possibly connecting late on day 1 (15 Sep), but is both quite far north and unfavoured for a significant connection at this time of year. CH69/+ may then connect on day 2 (16 Sep). Confidence is low however, due to its southern location and Earth currently being above the solar equator in its orbit, though Enlil has consistently forecast strong solar winds (around 600km/s) on day 2 and 3 (16 and 17 Sep) from this feature. Finally, a small small positive coronal hole near centre disk may bring elevated wind speeds at Earth for a time. This is most likely to occur on day 4 (18 Sep) or perhaps later, though the fast wind from this feature may be masked by any CME effects in coming days.

Generally Quiet to Active geomagnetic activity is expected day 1 (15 Sep) with a chance of G1-2/Minor-Moderate and an outside chance of G3-5/Strong-Extreme storms should the 14 Sep CME arrive early with more potency than currently expected. The 14 Sep CME should then arrive with glancing impacts some time on day 2 (16 Sep) with G1-2/Minor-Moderate expected and a chance of G3/Strong and a slight chance of G4-5/Severe-Extreme storms. These risks gradually step-down into days 3 and 4 (17 and 18 Sep) due to waning CME and coronal hole fast wind effects.

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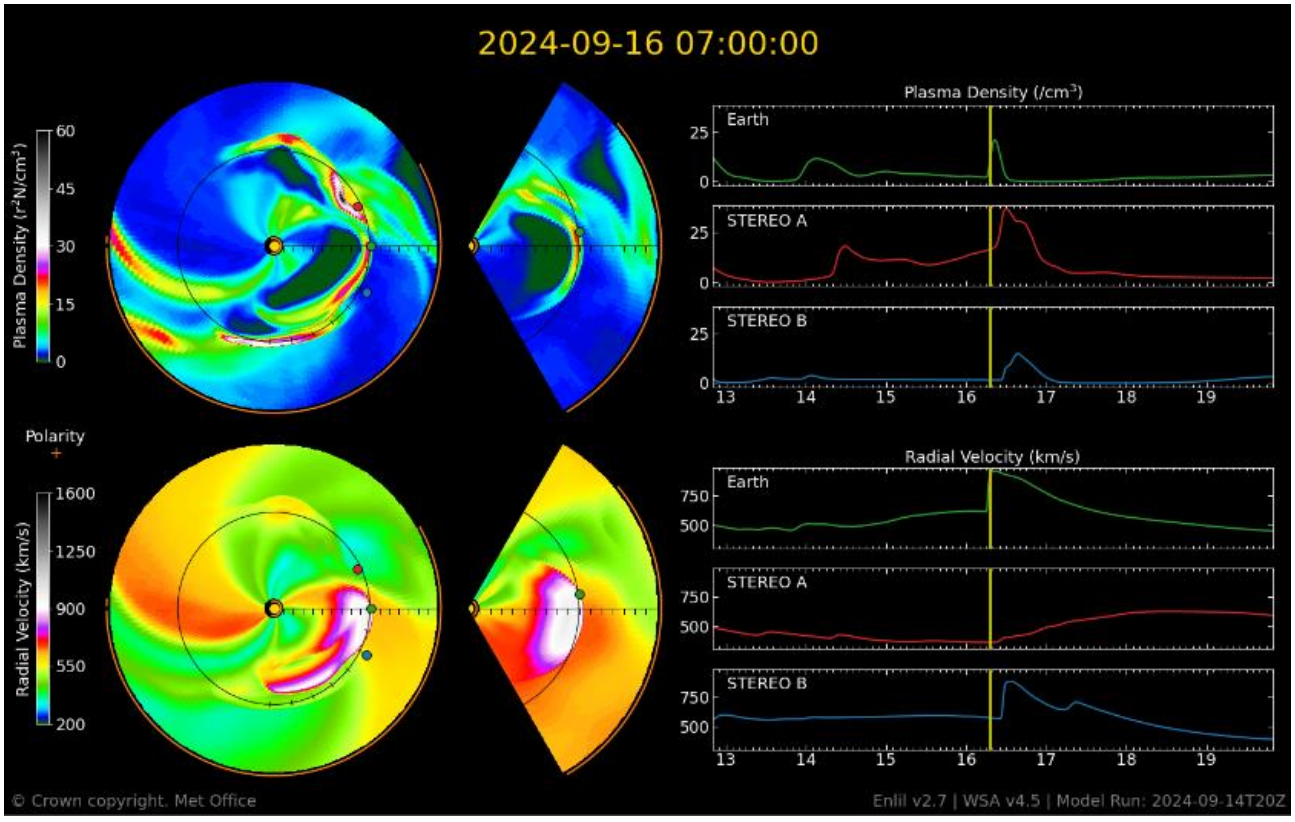
Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	40	80	50	20
Strong	G3	No	20	40	20	5
Severe	G4	No	5	10	2	1
Extreme	G5	No	2	2	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
14/1818	Partial	AR3825	SE	1250 km/s	16/0600UTC	Possible shock prior to any material arrival before this. Medium confidence.

Figure 2: MOSWOC ENLIL



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Radio Blackouts - X-Ray Flares:

Moderate to High activity is expected, with M-flares likely, and a slight chance of further X-class flares.

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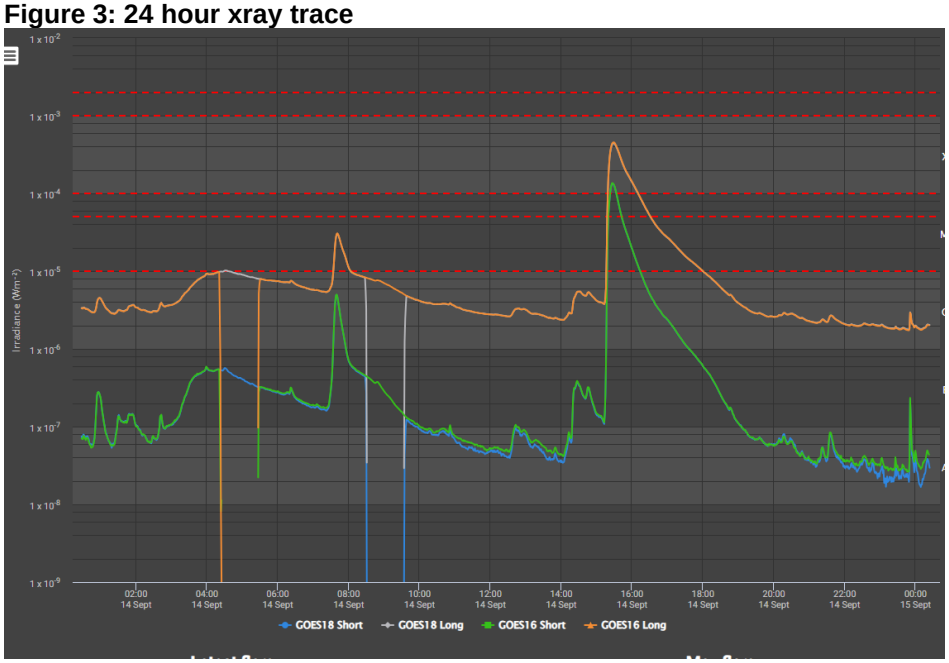
Further M-class flares are considered likely, with a slight chance of further isolated X-class flares, most likely from AR3825, this is held constant throughout the period due to AR3825 being the dominant spot on the disk which holds almost the entirety of the risk of flare risk.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	70	70	70	70
Very Active	R3 to R5 X Class	No	20	20	20	20

Figure 3: 24 hour xray trace



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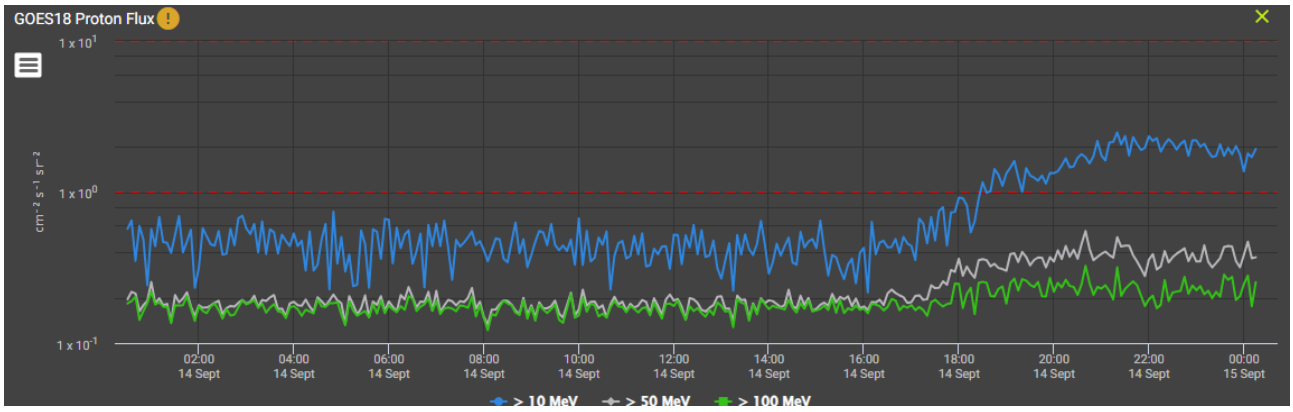
Solar Radiation Storms - (High Energy Protons):

High energy proton flux at GOES-18 has risen to moderate levels after the X4.5 flare on 14 Sep. A rising trend continues to be observed, though slow at present. Therefore there is therefore a chance that S1 proton storm levels may be reached day 1 (15 Sep), this risk reducing later in the period to a slight chance.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	30	20	10	10
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

Figure 4: 24 hour proton trace



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High Energy Electrons Event (≥ 2MeV):

The high energy electron flux has been rising to Moderate levels during the recent diurnal maximums due to recent geomagnetic storming that took place on 12 Sep. Now with at least two further CME arrivals anticipated and up to two coronal hols fast wind arrivals in the period, any rise is expected to be brief and the high energy flux most likely to stay close to Background levels.

The associated 24-hour fluence is expected to remain below the Active level. The latest MOSWOC REFM output is currently showing a rise, however this is misleading as it isn't taking into account any CME impacts or possible coronal hole interactions.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^{8}$	No	1	5	5	5
Very Active	≥ 2 MeV ≥ $1x10^{9}$	No	1	1	1	1

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